



Electricity Markets & Policy  
Energy Analysis and Environmental Impacts Division  
Lawrence Berkeley National Laboratory

# Cost of saving natural gas through efficiency programs funded by utility customers: 2012–2017

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May 2020



This work was supported by the U.S. Department of Energy's Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

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May 2020

The work described in this study was funded by the U.S. Department of Energy's Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

## Acknowledgements

The authors thank David Nemtzw, U.S. Department of Energy’s Building Technologies Office, for his support of our work, and the following reviewers: Jessica Allison and Jeorge Tagnipes, California Public Utilities Commission; Gregory Ehrendreich, Midwest Energy Efficiency Alliance; Donald Gilligan, National Association of Energy Service Companies; Martin Kushler, American Council for an Energy-Efficient Economy; Wally Nixon, Arkansas Public Service Commission; Jennifer Singh, New York State Energy Research and Development Authority; Rodney Sobin, National Association of State Energy Officials; David Springe, National Association of State Utility Consumer Advocates; and Donald Tormey, Iowa Utilities Board.

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## Acronyms and Abbreviations

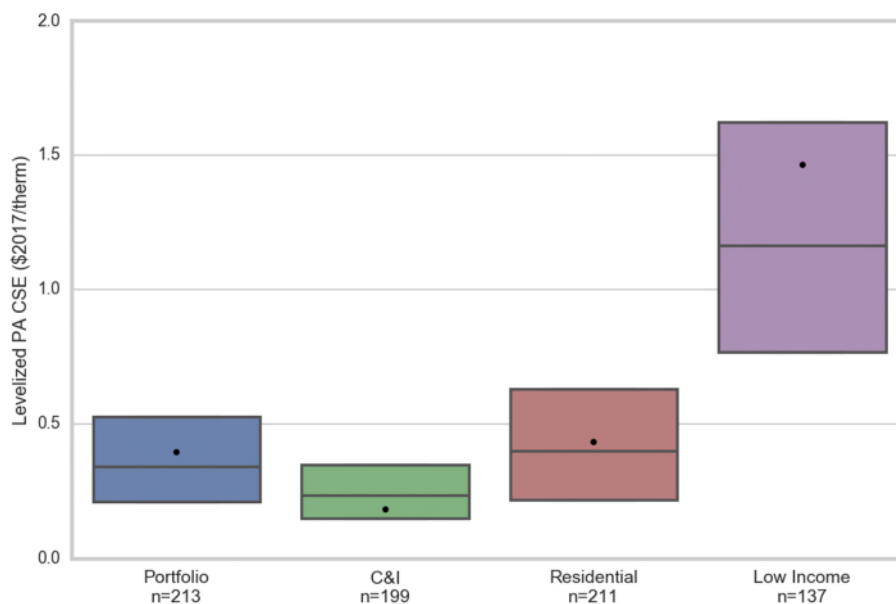
C&I	Commercial and industrial
CEE	Consortium for Energy Efficiency
CRF	Capital recovery factor
CSE	Cost of saved energy
EM&V	Evaluation, measurement and verification
EUL	Effective useful life
IOU	Investor-owned utility
NYSERDA	New York State Energy Research and Development Authority
PA	Program Administrator
PA CSE	Program Administrator Cost of Saved Energy
QAQC	Quality assurance, quality control
WACC	Weighted average cost of capital

## Executive Summary

Energy efficiency programs for customers of natural gas utilities provide multiple benefits, including improving energy affordability and resilience and easing gas pipeline constraints. Policymakers, state public utility commissions, utilities, and other program administrators rely on cost performance metrics, such as the cost of saved energy (CSE), to assess energy savings potential and design and implement programs in a cost-effective manner. In resource planning and implementation processes, accurate assessments of efficiency cost performance help ensure reliability at the most affordable cost.

Berkeley Lab earlier conducted an analysis of the cost of saving natural gas for the 2009–2011 period ([Billingsley et al. 2014](#)) through energy efficiency programs funded by customers of investor-owned utilities (IOUs). In this new study, Berkeley Lab collected publicly available cost and savings data for 2012–2017 reported by IOUs and other program administrators (PAs) in a dozen representative states (AR, CA, CT, IA, MA, MI, MN, NJ, NY, OK, RI and UT) that provide geographic representation in all four U.S. Census regions. Our analyses focus on estimating the PA levelized cost of saved energy (PA CSE) for three core sectors for natural gas: residential, low income, and commercial and industrial (C&I). We also aggregate these sectors to provide regional and national values.

We report savings-weighted averages and unweighted medians and interquartile ranges of the levelized PA CSE for natural gas in constant \$2017/therm (Figure ES 1). The savings-weighted average PA CSE for gas efficiency programs in these 12 states over the 2012–2017 period was \$0.40/therm. This is similar to our earlier estimate for the period 2009 to 2011—\$0.38/therm.



**Figure ES 1. National PA CSE for gas efficiency programs for our sample: 2012–2017 savings-weighted averages (dots), medians (horizontal lines within boxes) and interquartile ranges (boxes)**



For context, this figure represents the avoided costs for the natural gas commodity, plus transportation, delivery, and any storage costs. Some jurisdictions also consider additional avoided costs, including environmental factors and reduction in price risk.

Other findings include the following, subject to additional research:

- *C&I programs provided the lowest savings-weighted average cost of gas savings (\$0.18/therm), yet represented a minority of overall spending (about 20%).* The cost of savings for residential and low-income programs was \$0.43/therm and \$1.47/therm, respectively. Residential and low-income programs accounted for about three-quarters of national gas program spending in our dataset.<sup>1</sup>
- *The PA CSE for gas programs in our dataset varied by geographic region, with the largest differences between the Midwest (\$0.25/therm) and the West (\$0.59/therm).* Some of this difference is probably driven by the large amount of spending on low-income programs in our Western regional dataset and perhaps the difference in savings opportunities between cold versus temperate regions.
- *Within our dataset, the average PA CSE for natural gas trended downward from 2012 to 2017.* Part of the driver for this change appears to be a shift toward longer-lasting measures. Verifying this shift would require additional data collection and analyses.

Within each state, the number of PAs studied varies from one to a dozen. The number of programs and PAs for which data were collected also varies each year due to changes over time in state policy, PA reporting or data availability. Depending on the year, the Berkeley Lab dataset covers 32 to 37 PAs that account for about 50% to 70% of annual national spending on natural gas efficiency programs.<sup>2</sup>

We made significant efforts to ensure accurate representation of PA-reported costs and savings in our database. However, we experienced several data quality and data screening challenges, similar to those indicated in prior Berkeley Lab reports.<sup>3</sup> Thus, the CSE values provided in this report should be considered estimates for the PAs sampled.

With respect to data collection and analyses, we were able to generate defensible estimates for the PA cost of saving natural gas covering a large share of national program spending, despite some data challenges. Reporting of gas program data has improved in many states, but significant and meaningful opportunities remain for greater transparency, rigor and comprehensiveness, including estimating and reporting savings and measure lifetimes.

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<sup>1</sup> For the study period, residential programs represented about 48% of total spending in our sample and low-income programs about 28% of the total.

<sup>2</sup> Based on national spending on programs as reported by the Consortium for Energy Efficiency. <http://www.cee1.org/annual-industry-reports>.

<sup>3</sup> These challenges include inconsistent PA definition, estimation and reporting of savings metrics (e.g., varying definitions of net and gross savings), program costs, market sectors and program types. In particular, estimates of measure effective useful lifetimes, which are fundamental to calculating savings for levelized cost values, are often not consistently reported or are inconsistent in value for the same efficiency measures.

This work could be strengthened and supplemented with the following additional research:

- Expand data collection to other states for fuller geographic representation, larger sample size and greater confidence in the results
- Provide technical guidance and support to states and PAs for more consistent reporting and improvements in evaluation, measurement, and verification (EM&V) and estimation of savings from natural gas efficiency programs
- Conduct analyses to identify the drivers of a downward trend in the average PA CSE from 2012 to 2017, as well as factors such as climate that drive differences in the cost of saving gas across states
- Analyze PA CSE for gas by efficiency program type (e.g., residential new construction, industrial process, commercial heating, ventilating and air-conditioning)
- Develop a cost curve for gas efficiency programs<sup>4</sup>
- Assess the potential impact of PA size on cost
- Estimate the Total CSE for natural gas programs, including participant costs

#### Program, Sector and Portfolio Years

**Program years** represent spending and savings data for a *single program* for a single year. For example, data covering four years of spending and savings for a particular program represent four program years.

We rolled up all program year data to the market sector level for each program administrator to create **sector years**—the administrator’s total spending and savings data for *all programs* targeting a market sector for a specific year. The market sectors include Residential, Commercial and Industrial, Low Income and Cross Cutting (for programs and spending that span two or more sectors). We then aggregated the sector years by region and for the full dataset.

At the sector level, costs and savings are weighted averages of individual program costs and savings. Sector-level CSE values therefore reflect the influence of higher-volume programs in that sector and can be pulled up or down by those programs.

Sample sizes (n) in charts and tables are in **portfolio years** for results for the full dataset or all data for a region. Sample sizes are in sector years for results by market sector.

<sup>4</sup> Berkeley Lab created an electricity efficiency cost curve in Hoffman et al. (2018): <https://emp.lbl.gov/publications/cost-saving-electricity-through>. See Figure 4-11 in that report.

# 1 Introduction and Data Collection/Analyses Process

The Cost of Saved Energy project is a foundational initiative that supports many aspects of Berkeley Lab's ongoing work for DOE.<sup>5</sup> It is unique for the breadth and depth of data coverage and unbiased analysis of energy efficiency metrics that are used by utilities, grid operators, the energy efficiency industry, states, regional entities and national organizations. It is the only initiative that has:

- Assembled data on a national scale for efficiency programs for utility customers down to the program level using a common, multi-tiered typology of 62 detailed electricity efficiency program categories (Hoffman et al. 2013);
- Collected electricity program data on all available costs, including participant costs, in order to calculate total costs;
- Maintained a long-running data series for detailed efficiency program spending and savings;
- Prioritized data obtained directly from regulatory filings by individual PAs (utilities and third-party administrators); and
- Employed a rigorous data quality assurance/quality control (QAQC) regimen.

Berkeley Lab first reported on the cost of saving natural gas in 2014, based on data from 2009-2011 ([Billingsley et al. 2014](#)). U.S. natural gas prices have generally declined over the last 10 years,<sup>6</sup> putting pressure on the cost-effectiveness of natural gas efficiency programs. However, natural gas prices are expected to increase through 2025 and into the foreseeable future.<sup>7</sup> Understanding the cost of saving a therm remains important for assessing the value of energy efficiency programs.

With this context, our new analysis provides a needed update on the cost of saving natural gas. Berkeley Lab prioritized data collection among states and PAs where our effort would go farthest in achieving objectives for data coverage, using the following criteria:

- *Geographic diversity* – Data for at least two states with significant program spending in every U.S. Census region<sup>8</sup>
- *Data publicly available* – For all or most years from 2012 through 2017

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<sup>5</sup> The Cost of Saved Energy project is a continuing effort to understand the cost of energy efficiency from the program to portfolio level: <https://emp.lbl.gov/projects/what-it-costs-save-energy>. Recent projects include the cost of saving electricity, the cost of peak electric demand savings, and the cost of saving electricity for publicly owned utilities.

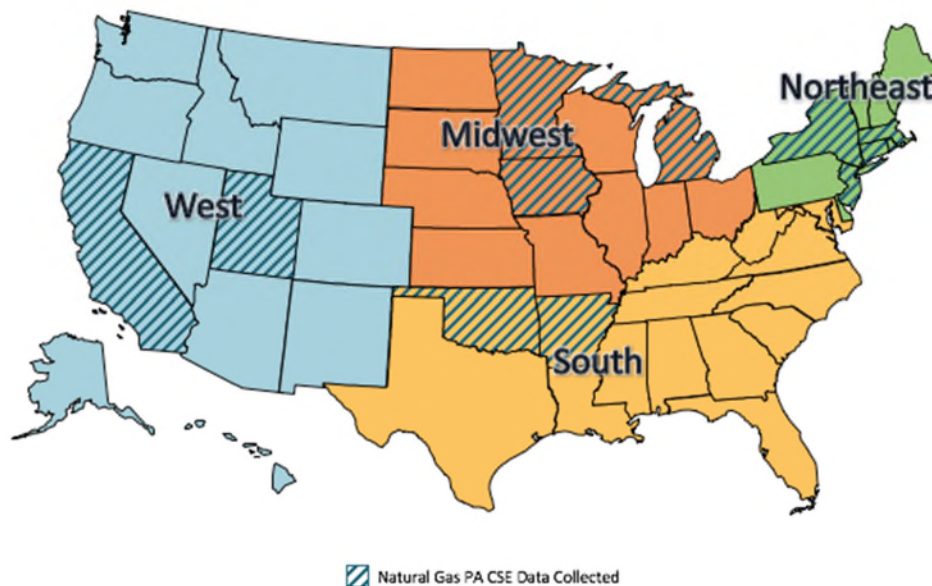
<sup>6</sup> See <https://www.eia.gov/dnav/ng/hist/n3050us3m.htm>.

<sup>7</sup> Annual Energy Outlook 2019, Reference Case, Table 1, <https://www.eia.gov/outlooks/aeo/data/browser/#/?id=1-AEO2019&region=0-0&cases=ref2019&start=2017&end=2050&f=A&linechart=~ref2019-d111618a.44-1-AEO2019&ctype=linechart&sourcekey=0>.

<sup>8</sup> [https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us\\_regdiv.pdf](https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf)

- *Data already in hand* – States and PAs where we had collected natural gas program data for these years as we updated our database for electricity analyses (particularly for dual-fuel utilities)
- *Share of national spending* – Focus on states with a high share of national gas efficiency program spending

Based on these criteria, we collected data for IOU programs in a dozen states for the period 2012-2017. With few exceptions, we collected data from state regulatory filings.<sup>9</sup> *Data in this report are based on reported costs and savings, and these values are not independently determined or validated by Berkeley Lab.* Figure 1 shows states where we collected data from some or all of the PAs (see Appendix 1) and the relevant U.S. Census region.



**Figure 1. States represented in our sample, by U.S. Census region**

Given program spending, data coverage is concentrated in the Northeast, Midwest and California. We included Utah, Arkansas and Oklahoma to provide geographic diversity. The resulting collection covers two states each in the West<sup>10</sup> and South, three states in the Midwest, and seven states in the Northeast. Table A - 1 in Appendix 1 provides further details on PAs and data years. Table A - 2 shows state by state spending on natural gas efficiency programs and totals. The share of national spending represented by our dataset ranges from

<sup>9</sup> Where we obtained data from other sources (e.g., state database queries in New York), we conducted spot checks against PA filings to ensure the fidelity of the database values.

<sup>10</sup> The sample size of PAs is smallest for the West and, as compared to the other three regions, data collected is heavily weighted towards low-income programs. See Appendix 1 regarding California programs.

about 50% to 70% by year for the period 2012-2017, based on Consortium for Energy Efficiency (CEE) estimates of national gas efficiency program spending.<sup>11</sup>

We standardized, validated,<sup>12</sup> and analyzed the gas program data we collected consistent with practices for Berkeley Lab research on the cost of saving energy. These practices and their rationales are documented in a series of reports (Billingsley et al. 2014, Hoffman et al. 2015, Hoffman et al. 2017, Hoffman et al. 2018). We also employed several decision rules and state-specific guidelines to resolve ambiguities, conflicts or missing values, as summarized in Appendix 2. For example, to facilitate aggregation and comparison at different levels of analysis, all savings were converted as necessary to gross therm savings, and all spending collected as nominal dollars was adjusted for inflation to 2017 dollars.

While about 40% of the underlying data are available at the program level, the analysis for this report focused on the three core market sectors: residential, low income and C&I. We characterized as “cross-cutting” programs or spending not associated with a single sector or which the PA indicated as portfolio-wide spending, such as research, brand marketing or planning. Given the limited number of programs in the cross-cutting category and the wide variation in their purpose, we do not report the PA CSE for cross-cutting programs in this report. However, we include all programs (including those characterized as cross-cutting) and expenditures in portfolio PA CSE values.

The metric we use for reporting and comparing natural gas efficiency costs is the levelized PA CSE, denominated in constant 2017 dollars per therm saved at the end-use site. The levelized PA CSE for natural gas is the cost of achieving natural gas energy savings over the estimated lifetime of the efficiency measures implemented, amortized over that lifetime and discounted back to the year in which the costs are paid and the actions taken. The levelized PA CSE is intended to account for expenditures in planning, administering, designing and implementing programs, and providing incentives to market allies and end users to take actions that result in energy savings, as well as the costs of verifying those savings.

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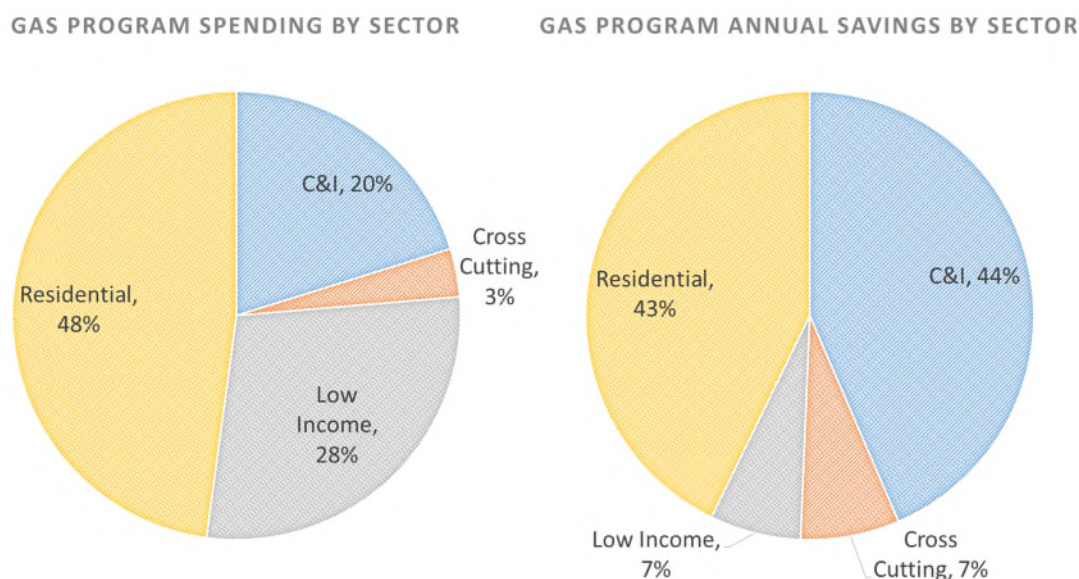
<sup>11</sup> CEE’s annual reports are at <http://www.cee1.org/annual-industry-reports>. Berkeley Lab’s data collection and discussions with CEE suggest that our database includes one category of committed spending that is reported by New York program administrators, but which CEE does not include in its annual reporting of the state’s actual spending on efficiency. This accounts for differences in Berkeley Lab and CEE numbers for New York.

<sup>12</sup> A researcher other than the data collector validated the data for each state by scrutinizing all savings and spending values for at least one PA in each year, for states with two or fewer PAs. For states with three or more PAs, the QAQC inspector validated data for at least two PAs each year. If any discrepancies were found, the QAQC inspector and the original collector devised a solution. We then finalized and analyzed the data.

## 2 Findings: Spending, Savings and Program Administrator Cost of Saving Natural Gas

Following are findings associated with our analyses of data collected from 12 states that represent a majority of national gas efficiency program spending in the United States.

Figure 2 illustrates for each market sector the relative shares of total spending and savings for the 2012–2017 period for the PAs in our sample.



*Note: Sector shares do not add up to 100% because of rounding.*

**Figure 2. Market-sector share of total natural gas efficiency program spending and savings for 2012–2017 for our sample**

Unlike electricity efficiency programs, where C&I programs account for the largest share of total spending, gas efficiency program spending tends to be directed toward the residential and low-income sectors, with 48% and 28% of the spending for gas programs in our sample, respectively. At the same time, C&I and residential sector shares of gas program annual *savings* are roughly equivalent (44% and 43%, respectively).

For low-income programs, the ratio of spending to savings is roughly four-fold for both fuels—28% of spending and 7% of savings for gas programs, compared to 9% of spending and 2% of savings for electricity programs.<sup>13</sup> However, low-income programs comprise more than three times the share of savings for gas programs (7%) than their share for electricity programs (2%). Thus, low-income programs have a greater influence on national average CSE values for natural gas programs, as compared to their influence on electricity program CSE values.

<sup>13</sup> See Hoffman et al. 2018 for shares of spending and savings by market sector for electricity programs.



## 2.1 Portfolio- and sector-level PA CSE

For this study, we used portfolio- and sector-level spending, savings and measure lifetime values to generate savings-weighted averages, unweighted medians and ranges of PA CSE values. The following tables and figures provide PA CSE values at the national portfolio and regional levels for the PAs in our dataset. The portfolio PA CSE values represent the cost of the gas efficiency resource, viewed in aggregate across all gas efficiency programs, including cross-cutting activities not associated with a single sector or which the PA indicated as portfolio-wide spending.

Table 1 provides savings-weighted average portfolio and constituent sector values for our entire sample. PA CSE values represent an estimate of national values.

**Table 1. PA CSE for gas efficiency programs by portfolio and sector for our sample: 2012-2017 savings-weighted averages and median PA CSE values<sup>14</sup>**

Sector	Annual Gross Savings <sup>15</sup> (millions of therms)	Spending (\$2017 Million)	Average PA CSE (\$2017 Million)	Median PA CSE (\$2017 Million)
Residential	587.3	\$2,283.7	\$0.43	\$0.40
C&I	598.1	\$989.6	\$0.18	\$0.24
Low Income	91.1	\$1,350.1	\$1.47	\$1.16
<b>Portfolio (All Sectors)</b>	<b>1,375.0</b>	<b>\$4,971.1</b>	<b>\$0.40</b>	<b>\$0.34</b>

For 2012–2017, the national average PA CSE for natural gas for our dataset was about \$0.40/therm.<sup>16</sup> We would expect this value to be higher considering our earlier estimate of about \$0.38/therm for gas programs operated during the period 2009–2011 (Billingsley et al. 2014) for several reasons, including the assumed impacts of inflation on efficiency program costs and the use of different base years (2017 versus 2012). While this new estimate for 2012–2017 includes data from more PAs, additional analysis is required to understand whether broadening our data collection further, including PAs operating in lower-cost environments, or other factors would explain why these estimates are similar.

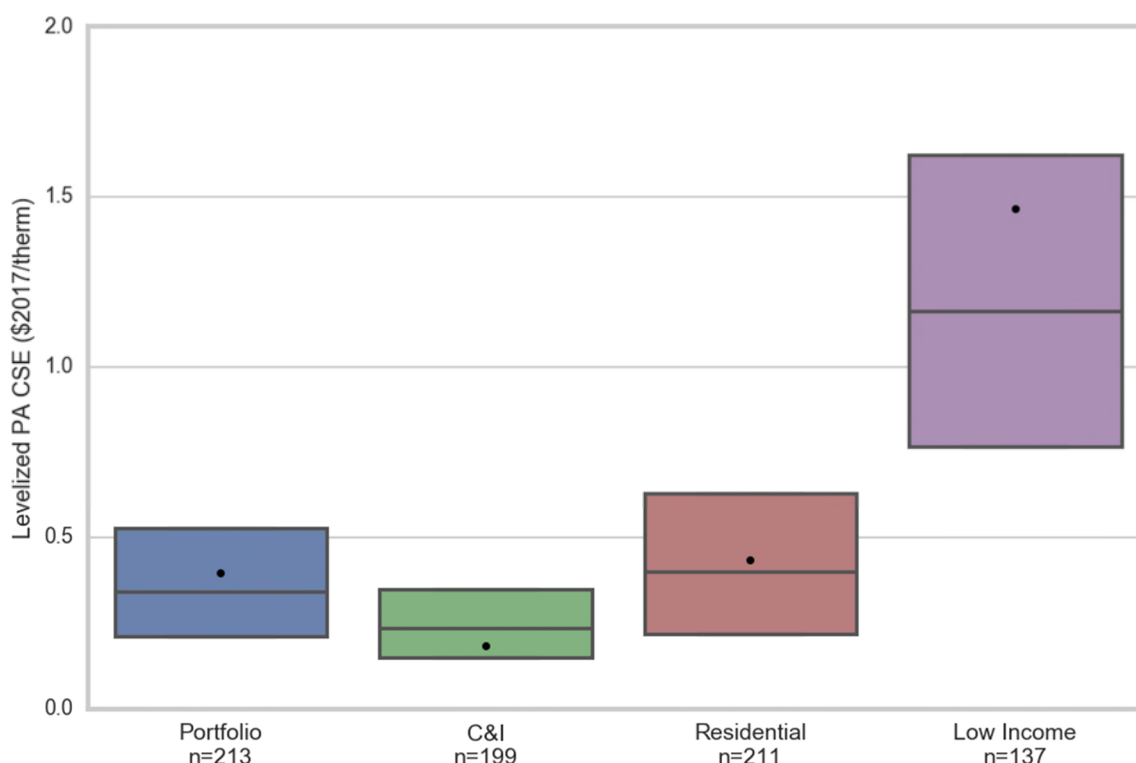
<sup>14</sup> Savings and spending for market sectors do not add up to the portfolio totals because portfolio values also include “cross-cutting” programs and portfolio-level costs such as planning and evaluation. These sector-level spending and savings totals only include programs that have both savings and spending, which are necessary for the calculation of the cost of saved energy.

<sup>15</sup> **Gross savings** are defined as the difference in energy consumption *with energy efficiency measures promoted by the program in place*, compared to what consumption would have been without those measures. **Net savings** are defined as the difference in energy consumption *with the program in place*, compared to what consumption would have been without the program. See Violette, D. and P. Rathbun (2017). [Chapter 21: Estimating Net Savings – Common Practices: Methods for Determining Energy Efficiency Savings for Specific Measures](#). National Renewable Energy Laboratory. Appendix 2 provides additional information.

<sup>16</sup> The PA cost of saving gas is highly sensitive to the discount rate used. Some jurisdictions consider a lower discount rate than the utility's WACC. For example, if we apply a 3 percent discount rate, the savings-weighted average PA CSE for gas efficiency programs in our 12-state sample over the 2012-2017 study period decreases from \$0.40/therm to \$0.33/therm, an 18 percent reduction.

Avoided costs of energy efficiency include the natural gas commodity as well as transportation, delivery, and any storage costs. Some jurisdictions also consider additional avoided costs, including environmental factors and reduction in price risk.<sup>17</sup>

Figure 3 depicts the national PA CSE savings-weighted averages at the portfolio and sector levels (dots), as well as the medians (horizontal lines) and the interquartile ranges (boxes). Unlike savings-weighted averages, where larger PAs have more influence over the national cost of savings than smaller PAs, the medians are more reflective of what a typical PA might experience.



**Figure 3. National PA CSE for gas efficiency programs for our sample: 2012-2017 savings-weighted averages (dots), medians (horizontal lines within boxes) and interquartile ranges (boxes)**

The ranges seen in Figure 3 at the national portfolio and market sector levels convey the variability in PA-level cost of savings. Such variability may be due to a range of factors including differences in efficiency measure mix, application and implementation differences, market or program maturity (e.g., higher costs for programs that are in startup phase or serving hard to reach communities), program efficacy and, perhaps most important, variability in underlying

<sup>17</sup> For example, see “Gas Avoided Cost Updates” in “Energy Trust Electric and Gas Avoided Cost Update for Oregon for 2018 Measure and Program Planning,” <https://www.energytrust.org/wp-content/uploads/2018/01/Energy-Trust-Avoided-Cost-Update-for-Oregon-2018.pdf>.



data quality. PAs estimate and report their costs and savings somewhat differently. Particular issues are associated with apparent differences in defining, determining and reporting net and gross savings, program category definitions, and the assumed effective useful life (EUL) of efficiency measures. For these and other reasons, caution is warranted with regard to the underlying quality, or at least consistency, of the savings determinations.<sup>18</sup>

Figure 3 implies several interesting findings associated with our dataset:

- As with electricity efficiency programs,<sup>19</sup> C&I programs tended to have less variability in costs than residential and low-income programs.
- However, unlike electricity programs, where residential programs have the lowest savings-weighted average cost of savings, gas C&I programs have the lowest cost of savings, whether indicated by average or median values.
- In the C&I sector, where the savings-weighted average PA CSE is lower than the median PA CSE, cost per therm may be lower at higher volume of savings.
- Low-income gas programs have a much higher PA CSE than programs for other sectors. This can be explained in part because, as with electricity efficiency programs, PAs tend to pay for 100% of measure costs for low-income programs (i.e., no cost share from program participants). In addition, our low-income program dataset is heavily influenced by California. The state maintains separate budgets, portfolios and cost-effectiveness requirements for its extensive low-income programs.<sup>20</sup> Combined with their breadth and comprehensiveness,<sup>21</sup> this results in higher CSE values. We discuss this further in the next section on regional findings.

## 2.2 Regional PA CSE for natural gas

The PA CSE for natural gas varied significantly from region to region. Figure 4 reflects this geographic variability.

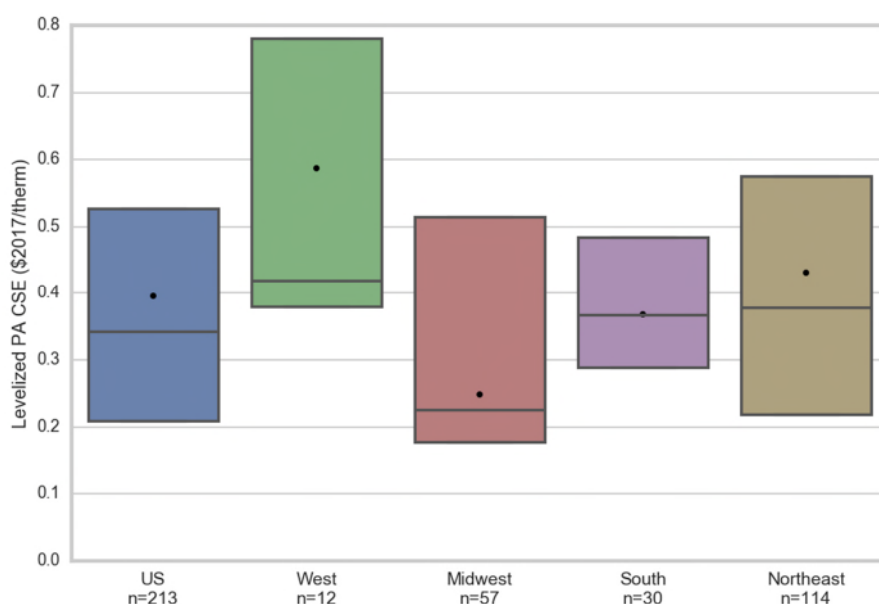
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<sup>18</sup> For example, we sometimes see values for the average EULs of program measures—a key driver of the PA CSE—that appear to be estimated in exact five-year increments (5, 10, 15, 20 years) or are applied across multiple consecutive years for a program, even though the mix of program measures differs from year to year. It also is not uncommon for a PA to correct values in one or more revisions or addenda to their annual reports, sometimes filed up to a year after the initial report. We also see extreme values, some obviously the result of error or inappropriate assumption, some not clearly erroneous.

<sup>19</sup> See Hoffman et al. 2018 for electricity program data.

<sup>20</sup> See California Public Utilities Commission (CPUC) Decision 16-11-022, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M169/K760/169760972.PDF>.

<sup>21</sup> The California [Energy Savings Assistance \(ESA\) Program](#) provides no-cost weatherization services to households whose total income is at or below 200 percent of the Federal Poverty Guidelines. Services provided include attic insulation, energy-efficient refrigerators, energy-efficient furnaces, weatherstripping, caulking, low-flow showerheads, water heater blankets, and door and building envelope repairs that reduce air infiltration (see [Energy Savings Assistance Program Policy and Procedure Manual](#)). The statutory objective of ESA is to meet the need for weatherization as determined by the CPUC through a low-income needs assessment study (see California Public Utilities Code Section 739). The Legislature directed the Commission to consider both the cost-effectiveness of the service and the policy of reducing hardships facing low-income households, co-equal goals which guide the CPUC's actions. Section 382(e) of the Code requires the Commission to ensure that all eligible low-income electricity and gas customers have the opportunity to participate in low-income energy efficiency programs by Dec. 31, 2020.



**Figure 4. PA CSE for natural gas by region for our sample: 2012-2017 savings-weighted averages (dots), medians (lines within boxes) and ranges (boxes)**

The Midwest, at \$0.25/therm, had significantly lower portfolio-level cost of gas savings than the other three regions. Climate probably plays a role here; the other regions are more temperate, resulting in lower savings associated with a furnace upgrade or weatherization, for example. The Midwest average was highly influenced by programs in Michigan and Minnesota, with colder climates. The PA CSE for gas in the West was more than twice the Midwest value at \$0.59/therm and was overwhelmingly driven by programs in temperate California. In a future study, a closer look at heating degree days for states or PAs in the sample could help isolate how much of the difference in the cost of gas savings is attributable to climate versus other factors.<sup>22</sup>

Table 2 further illustrates variability by providing sector-level values for each region.

<sup>22</sup> Another factor, at least in the future, is California PUC's requirement that each utility's portfolio of energy efficiency programs—except for low-income programs—must have a forecasted Total Resource Cost (TRC) of at least 1.25 by program year 2023. See Decision 18-05-041, May 31, 2018, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M215/K706/215706139.PDF>. Typically, states require a TRC of 1.0.

**Table 2. PA CSE for natural gas by region and sector for our sample: 2012–2017 savings-weighted averages**

Region	Sector	PA CSE (\$2017/therm)
Midwest	Residential	\$0.31
	C&I	\$0.11
	Low Income	\$1.01
	Portfolio (All Sectors)	\$0.25
Northeast	Residential	\$0.49
	C&I	\$0.23
	Low Income	\$1.05
	Portfolio (All Sectors)	\$0.43
South	Residential	\$0.46
	C&I	\$0.21
	Low Income	\$0.51
	Portfolio (All Sectors)	\$0.37
West	Residential	\$0.49
	C&I	\$0.23
	Low Income	\$5.06
	Portfolio (All Sectors)	\$0.59
All 12 States	Residential	\$0.43
	C&I	\$0.18
	Low Income	\$1.47
	Portfolio (All Sectors)	\$0.40

The cost of gas savings for all program sectors in the Midwest was lower than in other regions, except for low-income programs in the South. The weighted average PA CSE for the residential and C&I sectors in regions other than the Midwest was in fairly tight ranges: \$0.46–\$0.49/therm for the residential sector and \$0.21–\$0.23/therm for the C&I sector. As with electricity efficiency programs, the largest variability was in the low-income sector, driven in part by different measure mixes among low-income programs and climate, and probably different assumptions about magnitude and lifetime of measure savings (Billingsley, et al. 2014).

Depth and breadth of savings likely also played a significant role. The West had a far higher average PA CSE for low-income programs at \$5.06/therm, compared to about \$1/therm in the Midwest and Northeast and \$0.51/therm in the South. Perhaps tellingly, the average PA CSE for gas low-income efficiency programs for the Northwest, South and Midwest was about \$0.86/therm, a little over half the national average of our dataset.

The value in the West is driven by the large magnitude of Southern California Gas programs in our dataset. The utility spent about \$500 million (\$2017) on low-income efficiency programs in the 2012-2017 period.<sup>23</sup>

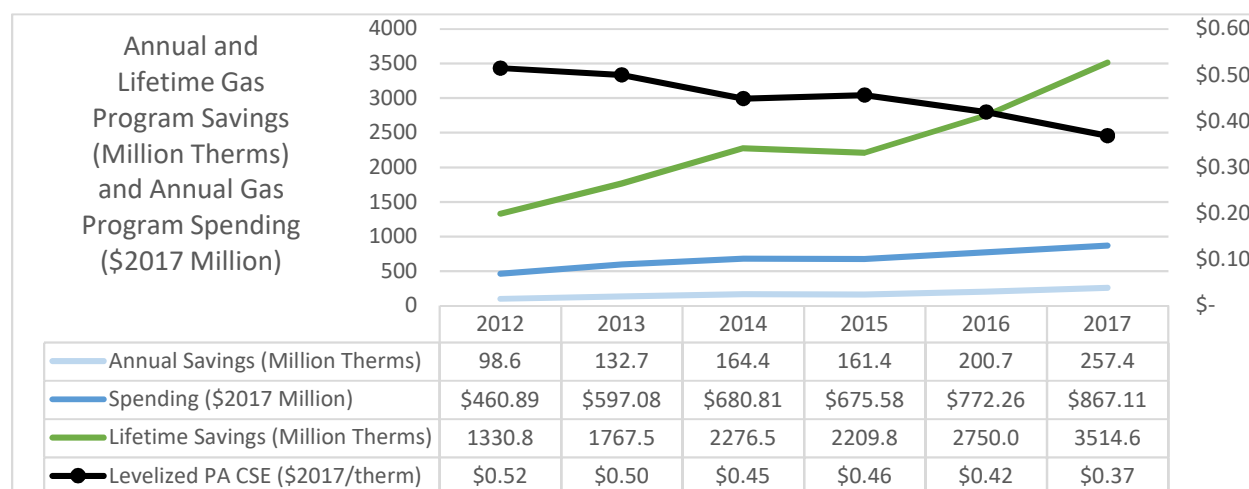
Programs for low-income customers have much lower participant contributions than most other program types and thus require a much higher cost contribution from program administrators than programs for other market sectors. In addition, repair work must be done in many cases before efficiency measures can be installed. Further, low-income programs often have aims beyond energy savings—for example:

- Reduced energy bills
- Improved safety
- Improved health of occupants
- Increased comfort

## 2.3 Trends in the PA CSE for natural gas

To assess changes in PA CSE over time, the set-up of the analysis must ensure any observed trend is real and not a product of PAs' reported spending and savings entering or leaving the dataset. Thus, for the trends analysis only, we constructed and analyzed a balanced panel—a consistent dataset for all PAs for which we had continuous data from 2012–2017.<sup>24</sup> The balanced panel focuses the trends analysis on a single, coherent group of PAs and changes in their markets, measures and other factors over the study period.

Figure 5 and the embedded table show the result of this trends analysis.



**Figure 5. Trend in the national gas PA CSE, savings-weighted averages for 2012–2017**

<sup>23</sup> Appendix 1 explains why we excluded from our analyses data we collected from California's dual-fuel utilities, Pacific Gas & Electric and San Diego Gas & Electric.

<sup>24</sup> For example, because 2017 data were not yet available for Detroit Edison and Consumers Energy—the only IOU gas program administrators in Michigan—we did not include the state in our trends analysis. For New York, where 2017 data were not available for NYSEDA and two small gas utilities, St. Lawrence and Corning, we excluded those PAs from the trends analysis.

On the primary (left) axis, annual savings and spending are in light and dark blue, respectively, and lifetime savings is in green. On the secondary (right) axis, PA CSE for gas efficiency programs is in black. Spending is in millions of constant 2017 dollars. Including all of these values helps explain the decline in the cost of gas savings for our trends analysis dataset. We observe the following from Figure 5:

- The national average PA CSE for gas efficiency programs declined over the 2012–2017 period.
- National gas program spending and savings increased over most of the period.
- Savings increased faster than spending (19% average annual growth versus 10%), resulting in the portfolio gas PA CSE declining by an average of about 7.2% per year.

Fully explaining the calculated decline in the gas PA CSE would require additional data and analysis. More data also would increase confidence in this result.

## 2.4 Observations and potential next steps

This targeted collection and analysis of natural gas efficiency program data in 12 states demonstrates the potential for estimating, evaluating and reporting the cost of saving gas at national and regional scales and for multiple market sectors. This information could serve as an important new resource for utilities, state and national decision-makers, and the energy industry as a whole. We are not aware of other, geographically representative estimates for the cost of gas savings.<sup>25</sup> Furthermore, while this effort underscores continuing challenges with completeness and rigor in savings estimation and program reporting, it also highlights opportunities for improvements as well as examples of exceptional estimation and reporting practices.

We observed wide ranges in the cost of gas savings by region and among market sectors. Yet within the residential and C&I sectors in most regions, we see fairly tight ranges. Identifying the nature of regional variability was beyond the scope of this study, but may be the result of just a few drivers, such as climate and the scope of low-income efficiency programs. We also noted relatively small differences between savings-weighted averages and medians at the market sector level, which suggests that the relationship of the reported costs and savings is roughly similar among PAs, regardless of size.

Further examination of the relationship of gas prices and efficiency program cost-effectiveness could provide meaningful insight into future gas savings from voluntary programs as an energy resource and source of savings for utility customers. In particular, this work could be expanded and enriched in several ways:

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<sup>25</sup> For example, the U.S. Energy Information Administration does not collect or publish data on gas efficiency programs as it does for electricity efficiency programs.

1. **Expand data collection and analysis** – Collecting additional states’ data would provide fuller geographic representation, larger sample size, more diversity and greater confidence in results.
2. **Provide technical guidance and support to states or utilities for improved reporting** – More comprehensive, consistent and rigorous reporting pays dividends for utilities, public utility commissions, program implementers, trade allies and other stakeholders (including researchers). Technical support could address improved reporting as well as underlying issues in EM&V, estimation of assumed savings and measure lives, and allocation of dual-fuel program costs by fuel and portfolio-level costs to programs. Berkeley Lab created guidance documents with recommendations on data collection and reporting for efficiency programs (Rybka et al. 2015).
3. **Analyze drivers of cost trends** – Analysis is needed to explain the drivers of the downward trend in the average PA CSE we observe from 2012 to 2017. In addition, analysis of heating degree days for states or PA territories could help isolate how much of the variation in the cost of gas savings is attributable to climate versus other factors.
4. **Estimate PA CSE for gas by efficiency program type** – Utility filings collected for this project contain data at the program level. Much of the data in major states (e.g., CA, NY, MA) were collected and standardized prior to sorting by sector and analysis. Thus, the data could be analyzed at the program level. A national program-level analysis would require additional time for data collection, not resolution of new challenges, and yield insight into the magnitude of savings and cost performance of various submarkets, measure classes and implementation strategies. We perform and publish such program-level analysis for electricity efficiency programs.
5. **Develop a cost curve for gas efficiency programs** – In 2018, Berkeley Lab introduced a cost curve for electricity efficiency programs that simultaneously depicts the magnitude of savings for individual program types and the cost of acquiring those savings (Hoffman, et al. 2018). A similar waterfall chart for gas efficiency programs would illustrate where PAs rely most for savings, how cost performance of those programs stacks up against gas prices, and how magnitude of savings might change in the future.
6. **Analyze costs by PA size** – Annual energy savings tend to be correlated with the size of the utility—its retail electricity load. Similar to our most recent comprehensive study of electricity efficiency programs (e.g., Hoffman et al. 2018), we could segment PAs into groups by annual energy savings to assess the potential impact of PA size on the cost of saving a therm.
7. **Estimate the Total CSE for natural gas programs** – Participating customers typically pay for a portion of efficiency project costs. In some cases, participants pay a significant share. Similar to our studies for electricity efficiency, a future study could collect participant costs for natural gas programs to develop estimates of the Total CSE—PA CSE (administrative costs and incentives) plus participant costs.

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## Appendix 1. Data Included in This Study

**Table A - 1. Spending and Savings Data Coverage by State, Program Administrator and Year**

State	PA	2012	2013	2014	2015	2016	2017
Arkansas	Arkansas Oklahoma Gas Corp.	*	*	*	*	*	*
	Black Hills Gas Distribution LLC	*	*	*	*	*	*
	CenterPoint Energy	*	*	*	*	*	*
California	SoCal Gas	*	*	*	*	*	*
Connecticut	Connecticut Natural Gas Corp	*	*	*	*	*	*
	Southern Connecticut Natural Gas Co.	*	*	*	*	*	*
	Yankee Gas Service	*	*	*	*	*	*
Iowa	Black Hills Energy	*	*	*	*	*	*
	Interstate Power and Light Co.	*	*	*	*	*	*
	MidAmerican Energy Co.	*	*	*	*	*	*
Massachusetts	Columbia Gas of Massachusetts	*	*	*	*	*	*
	NSTAR	*	*	*	*	*	*
	National Grid - Massachusetts	*	*	*	*	*	*
Michigan	Consumers Energy Company	*	*	*	*	*	
	Detroit Edison Company, The	*		*	*	*	
Minnesota	CenterPoint Energy	*	*	*	*	*	*
	Great Plains Natural Gas Co.	*	*	*	*	*	*
	Greater Minnesota Gas Co.	*	*	*	*	*	*
	Minnesota Energy Resources Corp.	*	*	*	*	*	*
	Xcel Energy dba Northern States Power Co.	*	*	*	*	*	*
New Jersey	NJCEP	*	*	*	*	*	*
New York	Central Hudson Gas & Electric Corp.	*	*	*	*	*	*
	Consolidated Edison Company of NY	*	*	*	*	*	*
	Corning Natural Gas Corp.	*	*	*	*		
	KeySpan Gas East Corp. dba KeySpan - Long Island	*	*	*	*	*	*
	National Fuel Gas Distribution Corp.	*	*	*	*	*	*
	Niagara Mohawk dba National Grid - NY Upstate	*	*	*	*	*	*
	New York State Electric & Gas Corp.	*	*	*	*	*	*
	NYSERDA	*	*	*	*		



<b>New York</b>	Orange & Rockland Utilities	*	*	*	*	*	*
	Rochester Gas & Electric Corp.	*	*	*	*	*	*
	St Lawrence Gas Company Inc.	*	*	*	*		
	Brooklyn Union Gas Co dba National Grid	*	*	*	*	*	*
<b>Oklahoma</b>	Centerpoint Energy	*	*	*	*	*	*
	Arkansas Oklahoma Gas Corp.	*	*	*	*	*	*
<b>Rhode Island</b>	National Grid - Rhode Island	*	*	*	*	*	*
<b>Utah</b>	Questar	*	*	*	*	*	*
<b>Total Portfolio Years</b>		37	36	37	37	34	32

**Table A - 2. Spending Data Included by State and Share of Estimated National Spending: 2012-2017 (\$M nominal)**

State	2012	2013	2014	2015	2016	2017
Arkansas	\$9.4	\$12.5	\$10.7	\$12.3	\$13.2	\$14.4
California	\$82.3	\$155.2	\$162.9	\$143.6	\$133.5	\$143.7
Connecticut	\$17.4	\$24.0	\$41.3	\$38.6	\$45.3	\$46.7
Iowa	\$40.6	\$36.6	\$45.0	\$53.8	\$54.8	\$56.3
Massachusetts	\$127.8	\$143.4	\$161.6	\$176.1	\$191.8	\$194.6
Michigan	\$73.6	\$73.4	\$64.7	\$45.0	\$66.4	Not Available
Minnesota	\$39.7	\$43.3	\$43.5	\$48.2	\$50.6	\$56.6
New Jersey	\$32.8	\$32.6	\$67.4	\$66.6	\$111.0	\$112.2
New York	\$95.5	\$174.5	\$253.1	\$245.5	\$98.3	\$177.8
Oklahoma	\$7.8	\$12.5	\$12.9	\$13.2	\$13.8	\$16.4
Rhode Island	\$12.3	\$17.8	\$20.0	\$20.1	\$22.2	\$26.1
Utah	\$19.8	\$29.0	\$26.3	\$23.5	\$23.3	\$22.4
<b>Total**</b>	\$559.0	\$754.7	\$909.4	\$886.5	\$824.3	\$867.1
U.S. Natural Gas Efficiency Program Spending (\$M) Reported by CEE	\$1,125	\$1,147	\$1,267	\$1,291	\$1,300	\$1,403
Percent of National Natural Gas Efficiency Program Spending Collected*	50%	66%	72%	69%	63%	62%

\* Berkeley Lab's database includes one category of committed spending that is reported by New York program administrators but which CEE does not include in its annual reporting of the state's actual spending on efficiency. This accounts for differences in Berkeley Lab and CEE numbers for New York.

\*\* Sum of state values may not add up to state totals due to rounding.

The share of national gas program spending covered in our analyses varies year to year for technical reasons, unavailability of data or policy shifts—in particular:

- *Interactive effects* – Dual-fuel utilities in California (Pacific Gas & Electric and San Diego Gas & Electric) report minimal or negative gas savings for a majority of their efficiency programs. The negative savings result from integrating into gas savings calculations interactive effects for dual-fuel programs. Installation of higher efficiency electricity measures reduces waste heat in buildings. That requires higher natural gas usage for space heating, which offsets gas savings from the program.<sup>26</sup> For this reason, for California, only Southern California Gas is included in our analysis. The other California IOUs do not report their full portfolios without interactive effects. Their data were therefore excluded from our analyses.
- *Data availability* – Data were not available at the time of collection (e.g., Michigan for 2017).
- *Some natural gas programs funded by customers ended* – For example, efficiency programs offered by the New York State Energy Research and Development Authority (NYSERDA) through its Clean Energy Fund are now supported solely by electricity customers. While some NYSERDA programs continue to save multiple fuels, programs funded by gas customers are currently winding down and will close out by February 2020. In addition, two small gas utilities in the state—Corning Natural Gas Co. and St. Lawrence Gas—stopped offering programs in 2016.

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<sup>26</sup> PG&E and SDG&E annual reports for *low-income* programs provide natural gas savings without interactive effects. We did not include that data in our analyses because data for the utilities' full portfolios were not available without such effects.

## Appendix 2. Decision Rules for Collection and Analyses of Natural Gas Program Spending and Savings Data

Given variability in the data reported by PAs, we established consistent rules and techniques for standardizing, aggregating, and analyzing data for “apples-to-apples” comparison of natural gas efficiency program and savings. The following rules and definitions support consistency and minimize uncertainty in the results, although such uncertainty is not possible to quantify.

**Gross savings:** Savings data of various types are separately tracked (e.g., distinct fields for claimed gross, claimed net, verified gross and verified net). For analysis, we prefer claimed gross savings, largely to avoid variability and lack of transparency in the definition and estimation of net savings. If claimed gross savings were not available, but gross verified savings were, we collected and used the verified gross savings value in analysis.

**Gross versus net savings:** If a state or program administrator reported net but not gross savings or stopped reporting gross savings, we collect program net-to-gross ratios, examine state practices in the estimation of net-to-gross ratios, and apply the results to “gross up” the reported net savings values.

**Gas volume-to-energy conversions:** Some program administrators report natural gas savings in volumetric terms, typically in Ccf (100 cubic feet) or Mcf (1,000 cubic feet). The average heat content of natural gas varies somewhat. We relied on the national average heat content for 2017, as reported by the U.S. Energy Information Administration: 10.37 therms per Mcf.

**Program administrator costs:** Program administrator costs include administrative, education, marketing and outreach, and EM&V costs as well as financial incentives paid to customers or contractors.

**Dual-fuel utilities:** If a program administrator reports a single value for spending on gas and electric energy efficiency programs, we separate that spending by fuel based on each fuel’s relative share of monetized program benefits or each fuel’s program-level share of incentives, if available.

**Ancillary costs:** Some ancillary costs associated with investments in energy efficiency are not included because they are either not reported, not included in program administrator annual reports, or not included in the standard definition of program administrator cost of saved energy. These excluded costs include performance incentives for the program administrator, the time and transaction costs incurred by participants (e.g., analyzing potential efficiency investments, getting the work done), and tax credits.

**Effective Useful Lifetimes (EULs) or measure lifetimes:** Average measure lifetimes for programs were rolled up and averaged at the sector and portfolio level in order to levelize the costs as

accurately as possible, using the equation below. EULs can be a significant source of uncertainty for levelized PA CSE values.

#### Equation for the levelized PA CSE:

$$\text{Program Administrator Cost of Saved Energy for Natural Gas} = \frac{\text{Capital Recovery Factor} * (\text{Program Administrator Costs})}{\text{Annual Natural Gas Savings (in therms)}}$$

where the Capital Recovery Factor (CRF) is:

$$CRF = \frac{r(1+r)^N}{(1+r)^N - 1}$$

r = the discount rate

N = the estimated program or sector lifetime in years, calculated as the savings-weighted lifetime of measures or actions installed by customers participating in a program

**Discount rate:** We used a 6% real discount rate as an approximation of the weighted-average cost of capital for an IOU.<sup>27</sup>

**Sector definitions and costs:** We defined residential, low income, and commercial and industrial (C&I) sectors in accordance with standard industry practice. We defined low-income programs as any programs employing income qualification with eligibility set at typical low-income thresholds. Multifamily programs of all types were assigned to the residential sector.<sup>28</sup> Market sector definitions are important because programs must be consistently characterized and sorted to properly differentiate the nature and duration of efficiency savings—and thus derive a cost of savings that reflects the underlying market, measures and costs as accurately as possible. We assigned any program that addresses a specific market sector to that sector even if no savings were claimed for that program. For example, we count the cost of a residential audit program as a residential sector cost even if the PA claimed no savings for the audits.

**Outliers:** Extreme values can arise for a number of reasons, some justified. We consider extreme values carefully, partly as another check on accuracy of the data we collect and partly

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<sup>27</sup> We use a real discount rate because inflation already is accounted for in the use of constant dollars (2017\$). Our real discount rate is a proxy for a nominal rate in the range of 7.5% to 9%, typical values for a utility weighted-average cost of capital (WACC). A utility WACC is the average of the cost of payments on the utility's debt (bonds) and its equity (stock), weighted by the relative share of each in the utility's funds available for capital investment. The utility WACC is often used by IOUs in their economic screening of efficiency programs.

<sup>28</sup> Some PAs count all or a subset of their multifamily programs in the C&I sector—e.g., programs that target system replacements or common areas, or programs promoting efficient new construction.

to determine whether these extreme values exert unwarranted influence over the averages, means and ranges that we calculate. We identify potentially anomalous values by employing a standard screen for all values above or below a band that is two standard deviations from the sample mean. We used this screen at the sector level and found a number of values outside of the band. Ultimately, we could not easily identify errors in these values and decided not to exclude them from the analyses.